

1 WHAT IS CLAIMED IS:

2

3 1. A separation system for separating liquid components of differing densities  
4 from a fluid mixture, the system comprising:

5 a flow conditioning apparatus and a cooperating liquid separation  
6 apparatus disposed downstream from and in fluid communication with the  
7 flow conditioning apparatus;

8

9 the flow conditioning apparatus having an inlet, an outlet and a swirl  
10 chamber extending along a curvilinear swirl axis and located between the  
11 inlet and the outlet, the inlet and outlet being configured to cooperate with  
12 the swirl chamber to induce the swirling of a fluid mixture about the swirl  
13 axis such that when a fluid mixture having liquid components of differing  
14 densities passes through the swirl chamber, centrifugal forces are  
15 imparted upon the liquid components to induce coalescence of droplets in  
16 at least one of the liquid components;

17 and the liquid separation apparatus being capable of separating liquids of  
18 differing densities;

19 wherein the existence of the coalesced droplets in a fluid mixture received  
20 from the cooperating flow conditioning apparatus by the separation  
21 apparatus enhances the separation efficiency of the liquid separation  
22 apparatus.

23

24 2. The system of claim 1 wherein at least one of the inlet and the outlet is  
25 configured to direct a fluid mixture to flow generally circumferentially about  
26 the swirl axis to induce the swirling of a fluid mixture in the swirl chamber  
27 when passing through the swirl chamber.

28

- 1 3. The system of claim 1 wherein at least one of the inlet and the outlet is  
2 configured to direct a fluid mixture generally tangentially to a surface  
3 enclosed by an inner wall of the swirl chamber to induce the swirling of a  
4 fluid mixture when passing through the swirl chamber.  
5
- 6 4. The system of claim 2 wherein both the inlet and the outlet are configured  
7 to direct a fluid mixture to flow generally circumferentially about the swirl  
8 axis to induce the swirling of a fluid mixture when passing through the  
9 swirl chamber.  
10
- 11 5. The system of claim 1 wherein the inlet directs a fluid mixture into the swirl  
12 chamber at a distance offset from the swirl axis to induce the fluid mixture  
13 to swirl helically about the swirl axis.  
14
- 15 6. The system of claim 1 wherein the inlet includes an inlet opening and the  
16 flow control apparatus includes a movable closure which cooperates with  
17 the inlet to control the size of the inlet opening.  
18
- 19 7. The system of claim 1 wherein the outlet includes an outlet opening which  
20 directs a fluid mixture to flow generally tangentially to the curved surface  
21 enclosed by the swirl chamber as the fluid mixture passes through the  
22 outlet opening.  
23
- 24 8. The system of claim 1 wherein the outlet includes a plurality of orifices.  
25
- 26 9. The system of claim 8 wherein the plurality of orifices are arranged in a  
27 spiral configuration relative to the swirl axis.  
28
- 29 10. The system of claim 8 wherein the orifices have peripheries which are  
30 generally elongate and curved.  
31

- 1 11. The system of claim 1 wherein the flow conditioning apparatus includes a  
2 plunger which moves relative to the outlet to control the flow of fluid  
3 through the outlet.  
4
- 5 12. The system of claim 1 wherein the swirl chamber is annular and is at least  
6 partially formed by cooperating inner and outer cylinders.  
7
- 8 13. The system of claim 12 wherein the outlet includes a plurality of spaced  
9 apart orifices formed in the inner cylinder.  
10
- 11 14. The system of claim 13 wherein the orifices are arranged in a spiral  
12 configuration relative to the swirl axis.
- 13 15. The system of claim 13 wherein the flow conditioning apparatus includes a  
14 movable member which moves relative to the orifices to adjust through  
15 which of the orifices the fluid mixture may pass.  
16
- 17 16. The system of claim 13 wherein the orifices are elongate and curved in  
18 periphery and direct a fluid mixture passing therethrough to spiral about  
19 the swirl axis  
20
- 21 17. The system of claim 13 wherein the flow conditioning apparatus includes a  
22 movable member which moves relative to the orifices to control through  
23 which of the orifices the fluid mixture may pass.  
24
- 25 18. The system of claim 1 wherein the flow conditioning apparatus acts as a  
26 choke to substantially reduce the pressure of a fluid mixture passing  
27 through the flow conditioning apparatus.  
28

- 1 19. The system of claim 1 wherein the swirl chamber has a spiral vane  
2 disposed therein to induce the fluid mixture to swirl when passing through  
3 the swirl chamber.  
4
- 5 20. The system of claim 1 wherein the swirl chamber is at least partially  
6 formed by a pair of substantially out of plane elbows which induce a fluid  
7 mixture to swirl when passing through the swirl chamber.  
8
- 9 21. The system of claim 1 wherein the flow conditioning apparatus is a control  
10 valve which controls the rate of flow.  
11
- 12 22. The system of claim 1 further comprising a gas separation apparatus  
13 disposed upstream of and in fluid communication with the flow  
14 conditioning apparatus.  
15
- 16 23. The system of claim 1 wherein the liquid separation apparatus is an oil  
17 and water separator.  
18
- 19 24. The system of claim 1 wherein the separation apparatus is one of a gravity  
20 separator, a hydrocyclone, and a membrane separator.  
21
- 22 25. The system of claim 1 further comprising a wellhead for an oil producing  
23 well disposed upstream from and in fluid communication with the flow  
24 conditioning apparatus.  
25
- 26 26. A method of separating liquid components of differing densities from a  
27 fluid mixture, the method comprising the steps of:  
28  
29 passing a fluid mixture having liquid components of differing densities  
30 through a flow conditioning apparatus, the flow conditioning apparatus  
having an inlet with an inlet opening, an outlet with an outlet opening; and

1 a swirl chamber disposed there between with the inlet and outlet being  
2 configured relative to the swirl chamber such that the flow of the fluid  
3 mixture through the inlet to the swirling chamber and out the outlet  
4 induces swirling of the fluid mixture with droplets of at least one of the  
5 liquid components coalescing; and  
  
6 passing the fluid mixture to a cooperating liquid separator apparatus  
7 wherein the liquid components of differing densities are separated with the  
8 efficiency of the separator apparatus being enhanced by the existence of  
9 the coalesced droplets created by the flow conditioning apparatus.

10 27. The method of claim 26 wherein the liquids, which are separated, are  
11 received from a wellbore.  
12

13 28. The method of claim 26 wherein:  
14 the swirl chamber extends along a swirl axis; and  
15 at least one of the inlet and the outlet directs the fluid mixture to flow  
16 generally circumferentially about the swirl axis.  
17

18 29. The method of claim 28 wherein:  
19 the outlet includes a plurality of orifices.  
20

21 30. The method of claim 29 wherein:  
22 the orifices are configured to direct the fluid mixture passing therethrough  
23 generally circumferentially about the swirl axis.  
24

25 31. The method of claim 26 further comprising the step of:

1 adjusting the size of at least one of the inlet opening and the outlet  
2 opening to control the rate of flow through the flow conditioning apparatus.

3 32. The method of claim 31 wherein:  
4 the flow conditioning apparatus acts as a choke to substantially reduce the  
5 pressure of the fluid mixture passing therethrough.  
6

7 33. The method of claim 26 wherein:  
8 the flow conditioning apparatus includes a pair of out of plane elbows  
9 which induce swirling of the fluid mixture passing there through.  
10

11 34. The method of claim 26 wherein:  
12 the flow conditioning apparatus includes a movable closure to control the  
13 rate of flow through the flow conditioning apparatus.  
14

15 35. The method of claim 26 wherein:  
16 at least one of the inlet opening and the outlet opening includes a plurality  
17 of orifices which direct fluid flowing therethrough to helical swirl about the  
18 swirl axis.  
19

20 36. The method of claim 26 wherein:  
21 the swirl chamber is formed by a cylinder and the inlet includes a plurality  
22 of inlets which are configured to direct the fluid mixture to flow generally  
23 circumferentially about the swirl axis to create a helical flow.  
24

- 1     37.    The method of claim 36 wherein:
- 2           the flow control apparatus is disposed down hole in a wellbore; and
- 3           a fluid mixture enters the orifices and swirls to separate oil and water
- 4           received from an oil production zone in the wellbore.
- 5
- 6     38.    A flow conditioning apparatus for conditioning a fluid mixture which has
- 7           liquid components of differing densities, the flow conditioning apparatus
- 8           comprising:
- 9           an inlet, an outlet, and a swirl chamber extending along a curvilinear swirl
- 10          axis, the inlet and outlet being configured to cooperate with the swirl
- 11          chamber to induce a fluid mixture having liquid components of differing
- 12          densities to swirl when passing through the swirl chamber.
- 13
- 14    39.    The flow conditioning apparatus of claim 38 further comprising a closure
- 15          member including a plunger which moves relative to the swirl chamber
- 16          and which controls the flow of a fluid mixture passing through the fluid
- 17          control apparatus.
- 18
- 19    40.    The flow conditioning apparatus of claim 39 wherein:
- 20          the swirl chamber is annular and is formed by an inner cylinder and an
- 21          outer cylinder
- 22
- 23    41.    The flow conditioning apparatus of claim 40 wherein:
- 24          a closure member move relative to the swirl chamber to control the flow of
- 25          fluid through the swirl chamber.
- 26
- 27    42.    The flow conditioning apparatus of claim 40 wherein:

- 1 the inner cylinder has an outlet including a plurality of orifices.  
2
- 3 43. The flow conditioning apparatus of claim 42 wherein:  
4 the plurality of orifices are arranged in a spiral pattern about the swirl axis.  
5
- 6 44. The flow conditioning apparatus of claim 42 wherein:  
7 the orifices are configured to direct a fluid mixture, passing through the  
8 orifices, generally circumferentially about the swirl axis..  
9
- 10 45. The flow conditioning apparatus of claim 44 wherein:  
11 at least one of the orifices has peripheries which are generally elongated  
12 and curved in shape.  
13
- 14 46. The flow conditioning apparatus of claim 40 further comprising:  
15 an exit conduit in fluid communication with the outlet.  
16
- 17 47. The flow conditioning apparatus of claim 41 further comprising:  
18 a drive mechanism for controlling the movement of the closure member.  
19
- 20 48. The flow conditioning apparatus of claim 47 wherein:  
21 the inlet includes an inlet conduit which extends generally perpendicular to  
22 the swirl chamber and is offset from the swirl axis so as to introduce a fluid  
23 mixture into the swirl chamber generally tangentially to the curved surface  
24 enclosed by the swirl chamber.
- 25 49. The flow conditioning apparatus of claim 38 further comprising:



1 a movable closure member which moves relative to the inlet to control the  
2 flow of fluid through the apparatus.

3

4 50. The flow conditioning apparatus of claim 49 wherein:

5 the movable closure member is a spiral vane disposed in the swirl  
6 chamber and a fluid mixture spirals about the vane when passing through  
7 the swirl chamber.

8

9 51. The flow conditioning apparatus of claim 50 wherein:

10 the spiral vane moves relative to the inlet chamber to vary the length of  
11 contact between a fluid mixture passing through the swirl chamber and the  
12 spiral vane.

13

14 52. A flow conditioning apparatus comprising:

15 an inlet, and outlet and a swirl chamber disposed there between and  
16 extending along a swirl axis; and

17 an adjustable closure member for adjusting the rate of flow through one of  
18 the inlet opening and the outlet opening;

19 wherein fluid helical swirls about the swirl axis when passing through the  
20 flow conditioning apparatus.